

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: 9/22/80

Project Title: GRANT-IN-AID FOR FLUID DYNAMIC STUDIES OF PROSTHETIC HEART VALVES

Project No: E-19-619

Project Director: DR. A. P. YOGANATHAN *ynice*

Sponsor: AMERICAN HEART ASSOCIATION, GEORGIA AFFILIATE

Agreement Period: From 7/1/80 Until 6/30/81

Type Agreement: GRANT (ACCEPTED BY GTRI 6/4/80)

Amount: \$11,000

Reports Required: TERMINAL SCIENTIFIC REPORT

Sponsor Contact Person (s):

Technical Matters

Contractual Matters

(thru OCA)

Ms. Ann Angelo, Program Director
American Heart Association
Georgia Affiliate
2581 Piedmont Road, N.E.
Atlanta, Georgia 30324
(404) 261-2260

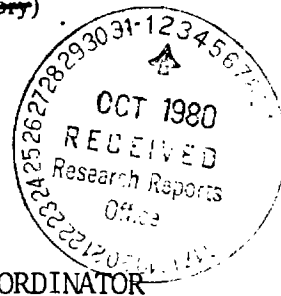
Defense Priority Rating: NONE

Assigned to: CHEMICAL ENGINEERING (School/~~Laboratory~~)

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GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT TERMINATION

Date: 6/18/81

Project Title: Grant-in-aid for Fluid Dynamic Studies of Prosthetic Heart Valves

Project No. E-19-619 (follow-on is E-19-661)

Project Director: Dr. A. P. Yoganathan

Sponsor: American Heart Association, Georgia Affiliate

Effective Termination Date: 6/30/81

Clearance of Accounting Charges: 6/30/81

Grant/Contract Closeout Actions Remaining:

- ☐ Final Invoice and Closing Documents
- ☒ Final ~~Final~~ Report of Expenditures
- ☐ Final Report of Inventions
- ☐ Govt. Property Inventory & Related Certificate
- ☐ Classified Material Certificate
- ☐ Other _____

Assigned to: Chemical Engineering (School/~~Laboratory~~)

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NOTICE OF RESEARCH PROJECT
SCIENCE INFORMATION EXCHANGE

SMITHSONIAN INSTITUTION
NATIONAL SCIENCE FOUNDATION
PROJECT SUMMARY

PROJECT NO. (Do not use
this space)

NSF AWARD NO.

1. NAME OF INSTITUTION (INCLUDE BRANCH/CAMPUS & SCHOOL OR DIVISION)

School of Chemical Engineering
Georgia Institute of Technology

2. MAILING ADDRESS

Atlanta, GA 30332

3. PRINCIPAL INVESTIGATOR AND FIELD OF SCIENCE/SPECIALTY

A. P. Yoganathan, Chemical Engineering / Polymers

4. TITLE OF PROJECT

Entrance and Exit Flows of Polymeric Fluids

5. SUMMARY OF PROPOSED WORK (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

It is proposed to study the velocity and stress fields in entrance and exit flows of polymer fluids. The emphasis is on the role of the viscoelastic rheological characteristics in determining the behaviors in stable flows as well as in the transition to unstable flows.

The planned work intends to adopt the technique of Laser-Doppler Anemometry which is sensitive and accurate enough to use for measurement at fluid velocities and velocity gradients much greater than those amenable to conventional techniques, such as streak photography. This tool will be used along with stress birefringence and streak photography to obtain a detailed quantitative and qualitative characterization of the flow fields.

Rheologically well-characterized fluids representing the range from the inelastic to the highly elastic spectrum of properties will be used in the proposed study. The comprehensive flow field measurements and rheological characterization are expected to provide the necessary experimental information for understanding the initiation and propagation of rate limiting instabilities in flow of polymers through geometries of both scientific and practical interest.

FOR NSF USE ONLY

DIVISION (OFFICE) AND DIRECTORATE	PROGRAM	
SECTION	PROPOSAL NO.	F.Y.

FOR DGC USE ONLY

START AND END DATES	AMOUNT GRANTED
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AMERICAN HEART ASSOCIATION-GEORGIA AFFILIATE
FLUID DYNAMIC STUDIES OF PROSTHETIC HEART VALVES
(GRANT-IN AID)
FINAL REPORT (7/1/80-6/30/81)

I. Principal Investigator: Professor A. P. Yoganathan, Georgia Tech
Collaborator: R. H. Franch, M.D., Emory University Medical School

II. Project Report

- (a) Even after 20 years of experience the problems associated with valve prostheses have not been totally eliminated. Some of these important problems, such as thrombus formation, hemolysis, tissue overgrowth and damage to the endothelial lining of the vessel wall adjacent to the valve are directly related to the fluid dynamics associated with the various valves. Detailed in vitro fluid dynamic studies of bioprostheses, the newest designs of mechanical heart valves, and valve conduits are being conducted. The in vitro laboratory data will be correlated with clinical and pathologic observations. It is hoped that the results of this research will lead to better and longer lasting heart valve prostheses and related cardiovascular products.

A fully operational left and right heart pulse duplicator system had been completed. Physiological pressure and flow wave forms have been obtained. As a left heart pulse duplicator the system contains a aortic valve chamber (with sinuses), and a mitral valve chamber which represents the left atrium and the left ventricle. The pulse duplicator has been interfaced to a Apple II Plus micro-processor for data collection and analysis. With the on-line micro-processor it is not possible to analyze pressure and flow information from the pulse duplicator beat by beat.

Photography studies of the opening and closing characteristics of the Carpentier-Edwards porcine aortic valves (sized #27 & 25) and Ionescu-Shiley pericardial aortical valves (sizes #27 & 25) have been conducted in the pulse duplicator allowing us to photograph the valve at any instant during the heart cycle. A series of six slides, showing the opening motion of a size #25 Ionescu-Shiley aortic valve under pulsatile flow is enclosed.

The photography studies indicate very clearly that the leaflets of the two bioprotheses do not open as ideally as the leaflets of the natural aortic valve. For example, a steady flow rate of $417 \text{ cm}^3/\text{sec}$ (25 liters/min) the #27 Ionescu-Shiley opens to about 67% of its primary orifice area while the #27 Carpentier-Edwards opens to about 61% of its primary orifice area. The #25 Ionescu-Shiley and Carpentier-Edwards valves open to about 74% and 54% of their primary orifice areas, respectively. It is also observed that the leaflets of the #25 Ionescu-Shiley valve open to a larger extent compared to the #27 Carpentier-Edwards valve under steady and pulsatile flow conditions. The results also show that the planimetered areas of valve leaflet opening for the Carpentier-Edwards valves have larger standard deviations compared to the Ionescu-Shiley valves. The reason for this is that the Ionescu-Shiley calf pericardial valves open more symmetrically and more reproducibly than the corresponding size Carpentier-Edwards porcine prostheses. Results of the opening of the valve leaflets under pulsatile flow conditions indicate that the Ionescu-Shiley valves open to about the same extent as under steady flow conditions. The Carpentier-Edwards valves, however, open to about 25 to 30% less compared to their corresponding steady flow rate valve leaflet openings. It was also observed that

IV. Publications

(a) Abstracts and Presentations

- (i) D. M. Stevenson, A. P. Yoganathan and R. H. Franch, The In vitro Fluid Dynamics of the Hall-Kaster and New Bjork-Shiley Heart Valve Prostheses. Presented at the Joint ASME/ASCE Mechanics Conference, Boulder, CO, June 22-24, 1981.
- (ii) A. P. Yoganathan, and R. H. Franch, In Vitro Fluid Dynamics of Tissue Bioprotheses. To be presented at the 2nd World Congress in Chemical Engineering, Montreal, Canada, Oct. 4-9, 1981.
- (iii) D. M. Stevenson, A. P. Yoganathan and R. H. Franch, Fluid Dynamics of Tilting (Pivoting) Disc Heart Valve Prostheses. To be presented at the 74th Annual AIChE Meeting, New Orleans, LA, Nov. 8-12, 1981.
- (iv) A. P. Yoganathan, In Vitro Flow Testing of Prosthetic Heart Valves. To be presented at the Bio-Engineering Symposium, ASME Winter Annual Meeting, Washington, D.C., Nov. 16, 1981.
- (v) A. P. Yoganathan, R. H. Franch and E. C. Harrison, Clinical Pathologic Problems Observed with Prosthetic Heart Valves: Possible Relationship to Fluid Dynamics. To be presented at the Bio-Engineering Symposium, ASME Winter Annual Meeting, Washington, D. C., Nov. 16, 1981.
- (vi) Organized and chaired a session on "Prosthetic Heart Valve Testing," at the 16th Annual AAMI Meeting, Washington, D. C. May 10-14, 1981.

(b) Manuscripts

- (i) D. M. Stevenson, A. P. Yoganathan and R. H. Franch, The Bjork-Shiley Heart Valve Prosthesis: Flow Characteristics of the New 70° Model. Accepted for publication in Scand. J. Thor. Cardiovasc. Surg.
- (ii) D. M. Stevenson, A. P. Yoganathan and R. H. Franch, Fluid Dynamics of Tilting (Pivoting) Disc Heart Valve Prostheses. In preparation.

V. Research Continuation

Work in this area is being actively pursued at Georgia Tech.

We have been awarded a continuation grant from your organization for \$10,500. This award is greatly appreciated. In addition, money has been provided by the School of Chemical Engineering at Georgia Tech to

purchase equipment for the Bio-Fluid Dynamics Laboratory, and to support graduate student stipends.